

PHYSICOCHEMICAL PROPERTIES, NUTRITIONAL AND ANTINUTRITIONAL COMPOSITION OF PULP AND PEEL OF THREE MANGO VARIETIES

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ABSTRACT

The physical and chemical properties of fruits are important indicators of their external and internal quality and also form the basis for studying chemical, nutritional and biochemical composition. Among the three varieties of mango, the physical properties of Totapuri were significantly higher compared to Alphonso and Kesar varieties. The total waste generated including peel and kernel was significantly higher in Totapuri (76.50 g) compared to Alphonso and Kesar (57.30 and 56.50 g, respectively). The ascorbic acid and pectin was significantly higher in peel (25.99 mg/100g and 18.92%) compared to pulp (18.87 mg/100g and 4.59%) respectively. The fat, crude fiber, total minerals, Calcium, phosphorous, zinc, iron, manganese and copper were significantly higher in peel compared to pulp irrespective of varieties. Phytic acid and oxalates were significantly higher in peel (25.48 mg/100g and 7.24 %) compared to pulp (0.61 mg/100g and 4.31 %). The green gram laddu incorporated with 15 per cent mango peel was highly acceptable by panels with high acceptability index 95.24 per cent. The green gram laddu prepared with kesar peel had higher sensory scores compared to alphonso and totapuri. The laddu prepared with mango peel contained higher β -carotene and dietary fiber compared to the green gram laddu.

KEYWORDS: Mango, Proximate, Laddu, Fiber and Carotene

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INTRODUCTION

India ranks second in production of fruits in the world, after China. During 2009-10, India produced 71.52 million metric tonnes of fruits with the area under cultivation of 6.33 million hectares. During 2010-11, India exported fruits worth of 2635 crores. Due to the short shelf life of these crops as much as 30-35 per cent of fruits perish during harvest, storage, grading, transport, packaging and distribution. Although India has a strong raw material base, it has been unable to tap the potential for processing and value addition to fruits. Only about two per cent of the fruits are processed into value added products, which is much lower when compared to other countries. Karnataka produces about 17.80 million MT of horticultural crops from an area of 1.87 million ha accounting to 7.40 per cent of total horticultural production in the country. Major share of production is from fruits (35.25%). Around 5.67 lakh MT of fruits have been traded in organized markets with average price of ₹17.47/kg (Singha, Choudhary, & Vishnu, 2014).

Mango (*Mangifera indica* L.), which belongs to the family Anacardiaceae, order Rutales, is one of the most important tropical fruits marketed in the world and is ranked fifth in total world production of major fruit crops (FAO, 2006). It is grown naturally or cultivated mainly in tropical and subtropical regions. Karnataka is the third largest mango producing state in the country and accounts for 11.7 per cent of mango production. The state is producing about 1.78 m. MT from an area of 0.16 m. ha. The productivity of mango in the state is 11.0 MT/ha. The production is concentrated in Kolar, Tumkur and Bengaluru districts. The commercial varieties grown in the state are Alphonso, *Totapuri*, *Banganapalli*, *Pairi*, *Neelum* and *Mulgoa*. Around 0.14 lakh MT of mango has been traded in organized markets with average price of ₹ 5.90/kg (Singha et al., 2014). Mango is also recommended for commercial planting as it has a high demand for direct consumption and for processing because of its pleasant flavor and unique taste. Mango, being a highly perishable seasonal fruit, suffers significant post-harvest wastage during its peak season, mainly as a result of inadequate handling. Poor post harvest technology is one of the major constraints to annual production, accounting for nearly 60–80% of losses (Djantou, Mbofung, Scher, & Desobry, 2007; Joseph & Abolaji, 1997). Extensive research in the area of plant breeding has generated hundreds of cultivars, the fruits of which show a pronounced diversity in size, color, flavor, seed size, and composition (Stafford, 1983). As mango is a seasonal fruit, it is processed into various products such as puree, nectar, leather, pickles, canned slices, etc., which have worldwide popularity (Loeillet, 1994). During the processing of mango, a massive quantity of peel is generated and is considered a waste by-product. Also, its disposal is a major problem, causing environmental pollution. The peel constitutes about 15 to 20 percent of the whole mango fruit. Peels have been shown to be a good source of nutrients, polyphenols, flavonoids, carotenoids, dietary fibres and other bioactive compounds that possess various beneficial effects on human health (C. M. Ajila, Bhat, & Prasada Rao, 2007; J. Larrauri, 1999; J. A. Larrauri, Rupérez, Borroto, & Saura-Calixto, 1996; Luthria, 2012; Wolfe, Wu, & Liu, 2003). Some of these compounds exhibit good antioxidant property (C. M. Ajila, Naidu, Bhat, & Rao, 2007).

Storage of agricultural materials and for converting these materials into food and processed product requires an understanding of their physical properties. Size and shape are most often used when describing grains, seeds, fruits, and vegetables. The shape and physical dimensions are important in sorting and sizing of fruits, and determine how many fruits can be placed in shipping containers or plastic bags of a given size. Quality differences in fruits, vegetables, grain and seeds can often be detected by differences in density. Quality is defined as the absence of defects or degree of excellence and it includes appearance, colour, shape, injuries, flavor, taste, aroma, nutritional value and being safe for the consumer (Abbott, 1999). Due to a higher market demand as for high-quality products, the juice and pulp industries have been looking for fruits with better internal and external features, including fruit length and width; fruit weight; pulp, seed and peel percentages per fruit; number of seeds per fruit; seed size and peel diameter; soluble solids (°Brix); titratable acidity (%); vitamin C content (mg/100g of fresh fruit); pulp pH and soluble solids/titratable acidity ratio. The maintenance of fruit quality characteristics (internal and external) demands postharvest handlings, such as: preventing mechanical injury, water loss and disease development, limiting unwanted physiological changes and preventing chemical and microbial contamination (Cook, 1999).

Physical properties of food ingredients are some of the properties, which define their visual characteristics and basic functionality. The physical and chemical properties of fruits are important indicators of their external and internal quality and decisive factors for the accomplishment of market demands. Information on physical characters of fruit forms the basis for studying chemical, nutritional and biochemical composition. Studies on fruit characterization can be helpful in selecting better quality fruits. Physical characteristics like size, shape, weight, volume *etc.* act as an important tool to

properly relate the nutritional, chemical and bioactive compounds in the fruits (Cavalcante, Martins, de Sousa Miranda, & Cavalcante, 2012).

Since, the fruit waste products selected for the present study do not belong to the category of foods, which are well known and often used, it was essential to record basic physicochemical characteristics, nutrient and antinutrient composition that would be beneficial in understanding the nature of mango peel. This would also help to utilise this potential mango waste for the health and nutrition security. *Laddus* are most popular sweets all over India. Varieties of *laddu* using cereal, pulse flour and nuts are prepared throughout India. A wide variation of *laddu* is available and according to their palate the *laddus* are prepared. In recent days *laddus* are available commercially at all sweets marts. Green gram *laddu* is common, most accepted easily digestible product having pleasant roasted aroma of green gram with sweetness of jaggery. In this study an attempt was made to incorporate mango peel powder in green gram *laddu* for value addition. The present study was conducted to evaluate the physicochemical properties, nutritional, antinutrient content of pulp and peel of three mango varieties and to utilize the mango peel in product development.

MATERIALS AND METHODS

Physical Properties of Whole Fruits

Whole mango fruits were used for measuring physical properties such as weight, volume, bulk density, length, breadth, width and circumference. Ten individual fruits were weighed using the digitalized sensitive balance average was calculated and expressed in Kilograms (kg). Volume of ten individual fruits was determined by water displacement method and average calculated. The results were expressed in milliliter (mL). Bulk density of the fruit was calculated using the readings of weight and volume. Length, breadth and width of the ten mangoes were obtained using the digital vernier caliper and expressed in millimeter (mm). Lengthwise circumference of fruit was measured by passing a thread around the fruit in upper, middle and lower part. The average of three measurements was calculated and expressed in centimeter (cm). Width wise circumference was measured using thread by passing around the fruit in upper, middle and lower part along the width of the fruit. The average of ten was calculated and expressed in centimeter (cm).

Processing of Mango

Three mango varieties namely *Alphonso*, *Kesar*, *Totapuri* collected from fruit outlets, Dharwad were washed separately in running tap water and wiped using a clean dry muslin cloth. The peel was separated using a sharp knife and the underlying pulp was removed by gently scraping with the knife's blunt edge. The kernel was separated from adhering pulp using a sharp knife. The weight of pulp, peel and kernel was recorded using digitalized sensitive balance and percentages calculated. The pulp was homogenized using a hand-held blender whereas the peel was cut into small pieces before being dried using a cabinet drier maintained at $50 \pm 2^\circ\text{C}$ for 12 h. Following drying, the peels were ground to a fine powder which was packed in polyethylene pouches and stored at -20°C for further chemical analysis.

Total Waste Generated from Mango

Total waste generated was calculated using the following formula Total waste generated = Weight of the (peel + kernel)

Edible Waste Generated from Mango

Percent edible waste generation of mango was calculated using the following formula

$$\text{Edible waste generated (\%)} = \frac{\text{Weight of the (peel + kernel)}}{\text{Weight of whole fruit}} \times 100$$

Total Waste Generated

Percent waste generation of each mango variety was calculated using the following formula

$$\text{Total waste generated (\%)} = \frac{\text{Weight of the total waste}}{\text{Weight of whole fruit}} \times 100$$

Chemical Parameters of Fresh Fruit

Moisture content of fresh three mango varieties was analyzed by oven drying method. Pulp and peel were dried in oven at a temperature of 50-55°C until constant weight was obtained (Ranganna, 1986) and percentages were calculated. The Total Soluble Solids (TSS) of three varieties of mango pulp was recorded using Erma Hand Refractometer. Titratable acidity was determined by titrating against 0.1N sodium hydroxide solution using phenolphthalein as an indicator (Ranganna, 1986). Results were expressed in terms of percent citric acid. The pH of three varieties of mango pulp was recorded with the help of pocket pH meter (Model, H196107 Hanna instruments pH cp). The fruits were macerated and used for measuring the pH. The total and reducing sugars were determined as per the procedure of Nelson-Somogyi (Ranganna, 1986) Non- reducing sugar was computed by subtracting reducing sugar from total sugar and multiplying with 0.95 a constant conversion factor

The microwave extraction of pectin was performed according to the methods described by (Maran, Sivakumar, Thirugnanasambandham, & Sridhar, 2014; Wang et al., 2007).

Nutrient Composition

The selected three varieties of mango pulp and peel were analyzed for proximate composition *viz*, moisture, crude protein, ash, crude fat, crude fibre using AOAC procedure and carbohydrate was computed. In addition dietary fibre, vitamins and minerals were estimated. All analysis was done in triplicate. The calorific value was calculated by summing up the values obtained by multiplying carbohydrate, protein and fat with Atwater constants. The values of carbohydrate, crude protein and crude fat were multiplied with 4, 4 and 9, respectively and expressed as kcal 100g⁻¹. The soluble, insoluble and total dietary fiber fractions were analyzed by an enzymatic method (Anon, 1995). Ascorbic acid content was determined by the volumetric method. (Ranganna, 1986). Total and β Carotene was estimated by HPLC method. (Krishna et al., 2001). Calcium was precipitated as calcium oxalate. The precipitate was dissolved in hot dilute H₂SO₄ and titrated against standard potassium permanganate (Oser, 1965). The trace elements (iron, zinc, copper and manganese) were estimated by wet digestion using a triacid mixture. A known aliquot of the test sample was suitably diluted and micronutrients in the test sample (Cu, Mn, Zn and Fe) were determined using Atomic Absorption Spectrophotometer (model: AAS GBS Avanta).

Antinutrient Analyses

The estimation of phytic acid was based on the principle that the phytate is extracted with trichloroacetic acid and precipitated as ferric salt (Wheeler & Ferrel, 1971). The iron content of the precipitate was determined colorimetrically and the phytate phosphorous content calculated from this value assuming a constant Fe : 6 molecular ratios in the precipitate. Phytates were estimated as phytic and the phytate phosphorus was obtained. Oxalates were extracted with hydrochloric acid, precipitated as calcium oxalate from the deproteinized extract and were estimated by subsequent titration with potassium permanganate (Dye, 1956).

Value Addition to Mango Peel

Procurement of Ingredients

Green gram flour, sugar, ghee and mango was procured in bulk from local market of Dharwad

Processing of Mango Peel

The processing of all the three mango varieties was done separately. The peel was separated using a sharp knife and the underlying pulp was removed by gently scraping with the knife's blunt edge. The peel was dried in a cabinet dryer at 40°C until the peel is moisture free. Lower temperatures were used to dry mango peel to retain the beta carotene content. The dried peel was powdered in pestle and mortar and packed in a polyethylene pouches and stored at -20°C for further use.

Protocol of Mango Peel Incorporated Green Gram Laddu

Green gram flour was roasted with the addition of ghee in a low flame until an aroma developed and sugar powder was added and a different proportion of mango peel (2.5, 5 and 10 %) was incorporated. The optimized value added products were analysed for proximate composition and trace minerals.

Sensory Evaluation

The products were subjected to organoleptic evaluation using 9 points hedonic scale (Amerine, Pangborn, & Roessler, 1965) by trained sensory panel of the Food Science and Nutrition Department (UAS-Dharwad).

Statistical Analysis

Statistical analysis was carried out using SPSS package. Student's 't' test, one-way and two-way ANOVA were used to assess the significant differences. Duncan's new multiple range test and correlations using Pearson's correlation coefficient were carried out.

RESULTS AND DISCUSSIONS

Physical Properties of Whole Fruits

The physical properties of mango varieties are depicted in Table 1. The weight and volume of Totapuri (287.00g and 261.50 ml) were significantly higher than Alphonso (231.90g and 214.40 ml) followed by Kesar (200.90g and 188.80 ml), respectively. However, the bulk densities of all three varieties of mango were statistically on par with each other (1.098, 1.082 and 1.0064 g/ml). Fruits of Totapuri variety were significantly longer (12.36 cm) than Alphonso (9.464 cm) and Kesar (9.565cm), the width and breadth did not differ significantly (7.08, 7.34, 6.566 and 6.66, 6.06, 5.80 cm), respectively. The weight of the pulp (190.30g) and peel (43.80 g) of Totapuri variety was significantly higher than the

Alphonso (168.10 and 32.00 g, respectively) while, Kesar recorded significantly lower values (140.20 and 25.70 g, respectively). The Alphonso (25.30) variety contained smaller kernel than Totapuri (32.70g) and Kesar (30.80g) which were on par with each other. The total waste generated including peel and kernel was significantly higher in Totapuri (76.50 g) compared to Alphonso and Kesar (57.30 and 56.50 g, respectively).

Chemical Properties of Whole Fruits

Table 2 depicts the chemical composition of pulp and peel of mango varieties. The pH of the pulp of Kesar was higher (4.53) than Totapuri (4.23) followed by Alphonso (4.10), however, this difference was statistically on par. Titratable acidity was significantly higher in pulp (0.25%) than in peel (0.12%), irrespective of variety. Among pulp of different varieties Alphonso pulp (0.29%) had significantly higher titratable acidity than Totapuri (0.25%) followed by Kesar (0.22%). A similar trend was observed in the peel of Alphonso (0.13%), Totapuri (0.12%) and Kesar (0.12%). With regard to the total soluble solids, the Kesar pulp had significantly higher (21.93 %) compared to Alphonso (19.80 %) and Totapuri (17.17%). Earlier studies of (C. M. Ajila, Bhat, et al., 2007; C. M. Ajila, Naidu, et al., 2007) reported that the TDF, IDF and SDF content in peels from different varieties of mango fruits at different stages of maturity varied from 45–78, 29–50 and 15–28, per cent respectively. Ascorbic acid was significantly higher in peel (25.99 mg/100g) compared to a pulp (18.87 mg/100g) irrespective of variety. Irrespective of a portion of fruit Alphonso contained significantly higher (24.31 mg/100g) ascorbic acid compared to Kesar (22.01 mg/100g) and Totapuri (20.97 mg/100g). When compared between peel between varieties the Alphonso (28.39 mg/100g) contained higher ascorbic acid than Kesar (25.50 mg/100g) followed by Totapuri (24.08 mg/100g). Total, reducing and non-reducing sugars were significantly higher in Alphonso pulp (19.32, 5.56 and 13.76 mg/100g) compared to Kesar (18.52, 15.75 and 4.15 mg/100g) and Totapuri (13.00, 3.47 and 9.53 mg/100g). The pectin content was significantly higher in peel (18.92%) compared to a pulp (4.59%) irrespective of variety. The pectin content was significantly higher in Kesar (12.99 %) than Alphonso (11.58%) followed by Totapuri (10.71%) irrespective of a portion of the fruit. (C. Ajila, Rao, & Rao, 2010) Ajila and co-workers (2010a) also reported the similar content of fibre and pectin. Recently, a screening study of 14 mango cultivars had demonstrated the content and degree of esterification of mango peel pectins to range from 12% to 21% and 56% to 66%, respectively (Berardini, Knödler, Schieber, & Carle, 2005).

Nutrient Composition

The proximate composition of mango varieties and their edible waste is presented in Table 3. A significant difference was observed between a portion of fruit (pulp and peel), between variety and interaction between portion and variety at $p \leq 0.01$ level of significance for moisture, fat, minerals, carbohydrate and calories. The moisture content was significantly higher in pulp (77.41%) compared to peel (10.43%) irrespective of varieties. Among varieties, Alphonso had significantly higher moisture (43.01%) compared to Kesar (39.53%) and Totapuri (37.54%). The protein content was not significantly different in mango pulp (0.77%) and peel (0.67%) irrespective of varieties. Whereas, between the varieties Alphonso had higher (0.79%) protein content than Kesar (0.67%) and Totapuri though not statistically significant. The fat, minerals, crude fiber and carbohydrate contents were significantly higher in peel (3.59, 3.49, 10.61 and 71.19 %, respectively) when compared to a pulp (0.75, 1.89, 0.52 and 18.67%, respectively) irrespective of variety and interactions. Among the varieties, the fat content was significantly higher in Totapuri (2.33%) compared to Kesar (2.19%) and Alphonso (1.99%) irrespective of pulp and peel. The total mineral content was significantly higher in Alphonso (2.87%) compared to Kesar and Totapuri (2.64 and 2.57%) irrespective of pulp and peel. The crude fiber was not significantly

different between the varieties irrespective of pulp and peel. The carbohydrate content was significantly higher in Kesar (49.46%) compared to Totapuri (48.82%) followed by Alphonso (45.55%) irrespective of a portion of the fruit. Peel possessed significantly higher energy (320 Kcal/100g) compared to a pulp (85.00 Kcal/100g) irrespective of varieties. The Totapuri variety of mango had the significantly higher energy (230 Kcal/100g) compared to Kesar (220 Kcal/100g) and Alphonso (203 Kcal/100g) irrespective of a portion of the fruit. The proximate composition of mango fruit pulp was 81% moisture, 0.6% protein, 0.4% fat, 0.4% minerals, 0.7% fibre and 16.9% carbohydrate as reported by (Gopalan, Rama Sastri, & Balasubramanian, 1971). The proximate composition reported was comparable to the earlier reported values in the peels of Badami and Raspuri varieties of mango (C. M. Ajila, Bhat, et al., 2007).

Table 4 represents the mineral content of pulp and peel of mango varieties. There was a significant difference in the calcium, phosphorus, iron manganese and copper between the portion of the fruit (pulp and peel). The mango peel contained significantly higher amounts of calcium, phosphorus, iron, manganese and copper (18.05, 19.82, 0.49, 0.37 and 0.07 mg/100g) when compared to a pulp (12.77, 15.73, 0.28, 0.15 and 0.04 mg/100g), irrespective of varieties and interaction between a portion of fruit and varieties. Whereas, a significant difference was not observed between pulp (0.19mg/100g) and peel (0.23 mg/100g) for zinc. Kesar variety had the significantly higher amount of calcium and iron (15.61 and 0.46 mg/100g) compared to Totapuri (15.18 and 0.31mg/100g) and Alphonso (15.43 and 0.37 mg/100g) irrespective of a portion of fruit and interaction. The phosphorus was significantly higher in Alphonso (18.31 mg/100g) compared to Kesar and Totapuri (17.73 and 17.28 mg/100g).Significantly, higher amounts of manganese (0.33 mg/100g) were recorded in Totapuri compared to Kesar (0.26 mg/100g) followed by Alphonso (0.21 mg/100g). The copper content was significantly higher in Kesar variety (0.07 mg/100g) compared to other two varieties (0.05 and 0.05 mg/100g). There was no significant difference in the zinc content between the portion of fruit, varieties and interaction.

Dietary Fiber

Figure 1 shows the dietary fiber content of pulp and peel of mango varieties. Mango pulp had significantly lower insoluble, soluble and total dietary fiber (4.35, 3.33 and 7.68%, respectively) compared to peel (33.19, 6.28 and 39.47 %, respectively) irrespective of variety. Alphonso variety had significantly higher insoluble soluble and total dietary fiber (22.29, 5.73 and 28.02 %, respectively) compared to Kesar (18.55, 4.67 and 23.22%, respectively) and Totapuri (15.47, 4.01 and 19.48 %, respectively) irrespective of a portion of fruit.

The β -Carotene

Figure 2 depicts the β - carotene content of pulp and peel of mango varieties. The β - carotene content was significantly higher in peel (47.85 mg/100g) compared to pulp (26.41 mg/100g) with irrespective of varieties, which was comparable to the carotenoid content reported in peel from Raspuri mango variety (3337 μ g/g) by (C. Ajila et al., 2010; C. M. Ajila, Bhat, et al., 2007; C. M. Ajila, Jaganmohan Rao, & Prasada Rao, 2010; C. M. Ajila, Naidu, et al., 2007).Significantly higher β -carotene in the Kesar (51.92 mg/100g) compared to Alphonso (41.99 mg/100g) and Totapuri (17.47 mg/100g) irrespective of portion of fruit.

Antinutrient Content

Significant difference existed in the phytic acid and oxalate content of the portion of the fruit and of the varieties at $p \leq 0.01$ percent significance level (Table 5). The phytic acid was significantly higher in mango peel (25.48 mg/100g) compared to a pulp (0.61 mg/100g) irrespective of variety. The phytic acid content was significantly higher in Kesar

variety (17.17 mg/100g) compared to Alphonso (13.06 mg/100g) followed by Totapuri (8.90 mg/100g) irrespective of a portion of fruit. The oxalate content was significantly higher in mango peel (7.24%) compared to a pulp (4.31 %) irrespective of varieties. Similar to phytic acid the oxalate content was significantly higher in Kesar (6.52%) compared to Alphonso (5.14%) followed by Totapuri (5.66%) variety irrespective of a portion of fruit.

Product Development and Optimisation

Table 6 depicts the optimisation of incorporation of Kesar mango peel in green gram *laddu*. The green gram *laddu* incorporated with Kesar mango peel powder up to 15 per cent was significantly and highly acceptable and had received higher sensory scores for all attributes appearance, colour, texture, aroma, flavour, taste and overall acceptability (8.20, 8.30, 8.50, 8.60, 8.80, 8.80 and 8.80, respectively). The acceptability index was very high (95.24%). This level of incorporation had the pleasant flavour of mango which was liked by most of the consumers and the peel of the mango had a crunchy texture and gave the textural variation in smooth laddus. The *laddu* incorporated with 20 per cent of mango peel received significantly lower sensory scores though acceptable for appearance (8.00), colour (7.70), texture (7.80), aroma (7.60), flavour (7.70), taste (8.30), overall acceptability (8.33) and acceptability index (86.19). The 15 percent level of incorporation of mango peel in *laddu* was used for further study.

Table 7 shows the organoleptic evaluation of mango peel incorporated in green gram *laddu*. There was no significant difference in the appearance and taste of mango peel *laddu* prepared Alphonso (7.80), Kesar (8.20) and Totapuri (7.90). However the colour, texture, aroma, flavour and overall acceptability of *laddu* incorporated with Kesar peel (8.30, 8.50, 8.60, 8.80, 8.80 and 8.80, respectively) were significantly higher than Totapuri (7.70, 7.30, 7.50, 7.30, 7.60 and 7.70) and Alphonso (7.20, 6.60, 7.20, 7.40, 7.40 and 7.50, respectively). The acceptability index was noticeably higher for aKesar peel (95.24%) followed by Totapuri (84.13%) and Alphonso (80.80%). This might be due to the pleasant flavour and texture of the kesar peel which was crispier while that of alphonso and totapuri was leathery.

Table 8 depicts the effect of incorporation of mango peel powder on nutrient composition of green gram *laddu*. The *laddu* prepared with mango peel contained higher β -carotene (202.39 μ g/100g), crude fiber fiber (5.55%), Iron (2.11mg/100g) and copper (.78 mg/100g) compared to the green gram *laddu* (44.2 μ g/100g , 4.65%, 1.87 mg/100g 0.67 mg/100g) respectively.

CONCLUSIONS

The peel is considered an edible tissue of the unripe mango fruit. Using unripe mango fruit with its peel, *chutneys* and pickles are prepared. On the other hand, peel of the ripe mango fruit, due to its leathery texture, is not too acceptable taste-wise; therefore, the peel is generally removed and discarded. Thus, in the food processing industry, mango peel ends up generally as a waste by-product. The present investigation was carried out to analyze the physical characteristics and biochemical composition of pulp and peel of mango varieties. From the study it was concluded that the physical parameters and biochemical composition varied in the variety and influenced the nutritional composition. The pulp and peel of three mango varieties differ among themselves in the length, width, breadth, acidity, waste generated and flavour. The information on composition of fruit and their edible wastes helps to understand the amount of nutrients which go a waste. The mango peel powder is a potential for food formulation because of its high content of nutrients, minerals, dietary fiber, carotene and bioactive compounds. The green gram *laddu* incorporated with kesar mango peel powder up to 15 per cent was significantly highly acceptable with acceptability index of 95.24 and contained higher β -carotene compared to the

green gram *laddu*. Thus mango peel powder is edible and rich in nutrient and bioactive compounds can be used as a sprinkler or incorporated in variety of food preparations to enhance nutraceutical value of the foods. Development and utilization of such functional and nutritional products can be used to provide health benefits by preventing degenerative diseases.

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APPENDICES

Table 1: Physical Properties of Mango Fruits of Different Varieties

Particulars	Mango Varieties			Mean	SEm±	CD
	Alphonso	Kesar	Totapuri			
Weight (g/fruit)	231.90 ± 29.92 ^b	200.90 ± 17.94 ^c	287.00 ± 16.81 ^a	239.93 ± 42.15	0.88	3.437**
Volume (ml/ fruit)	214.40 ± 28.32 ^b	188.80 ± 17.99 ^b	261.50 ± 20.13 ^a	221.57 ± 37.59	0.83	3.246**
Bulk density (g/ml)	1.08 ± 0.02 ^{ab}	1.06 ± 0.02 ^b	1.10 ± 0.03 ^a	1.08 ± 0.03	0.02	0.069*
Length (cm)	9.46 ± 0.51 ^b	9.57 ± 0.51 ^b	12.36 ± 0.42 ^a	10.46 ± 1.44	0.51	2.011**
Width (cm)	7.34 ± 0.33 ^a	6.57 ± 0.26 ^b	7.08 ± 0.17 ^a	6.99 ± 0.41	0.26	1.077**
Breadth (cm)	6.06 ± 1.21 ^b	5.80 ± 0.18 ^{ab}	6.66 ± 0.22 ^a	6.17 ± 0.78	0.38	1.097*
Weight of pulp (kg)	168.10 ± 21.65 ^b (72.488)	140.20 ± 12.37 ^c (69.786)	190.30 ± 13.36 ^a (66.307)	166.20 ± 26.13 (69.270)	0.69	2.706**
Weight of peel (kg)	32.00 ± 6.96 ^b (13.799)	25.700 ± 4.191 ^b (12.792)	43.80 ± 14.12 ^a (15.261)	33.83 ± 11.86 (14.101)	0.47	1.823**
Weight of kernel (kg)	25.30 ± 4.83 ^c (10.909)	30.800 ± 5.473 ^b (15.331)	32.70 ± 5.93 ^a (11.393)	29.60 ± 6.13 (9.836)	0.34	0.971*
Ratio of pulp : peel	5.25	5.46	4.34	5.017	-	-
Total edible waste generated kg (peel)	32.00 ± 6.960 ^b	25.700 ± 4.191 ^c	43.800 ± 14.117 ^a	33.833 ± 11.856	0.465	1.823**
Total waste generated kg (Peel + kernel)	57.30 ± 10.843 ^b	56.500 ± 9.265 ^b	76.500 ± 14.646 ^a	63.433 ± 14.769	1.07	4.189**

Note 1: Values are mean of ten replications, SEm- Standard error of mean, CD- Critical difference, NS- Non Significant, * Significant @5%, ** Significant @ 1 %.Values with the same superscripts (a, b) in the same row are not significantly different (p≤0.01). Figures in parenthesis indicate percentage

Table 2: Chemical Composition of Pulp and Peel of Mango Varieties

Parameters	Mango Varieties										
	Alphonso			Kesar			Totapuri			Mean	
	Pulp	Peel	Mean	Pulp	Peel	Mean	Pulp	Peel	Mean	Pulp	Peel
pH	4.10 ± 0.10 ^b	-	-	4.53 ± 0.06 ^a	-	-	4.23 ± 0.21 ^{ab}	-	-	4.29 ± 0.12	-
Titrateable acidity (%)	0.29 ± 0.01	0.13 ± 0.01	0.21 ± 0.09 ^a	0.22 ± 0.00	0.12 ± 0.00	0.16 ± 0.05 ^c	0.25 ± 0.00	0.12 ± 0.01	0.18 ± 0.07 ^b	0.25 ± 0.0	0.12 ± 0.01
Total soluble solids (Brix)	19.80 ± 1.59 ^{ab}	-	-	21.93 ± 0.57 ^a	-	-	17.17 ± 0.15 ^b	-	-	19.63 ± 2.24	-
Ascorbic acid (mg/100g)	20.22 ± 0.11	28.39 ± 0.55	24.31 ± 4.49 ^a	18.52 ± 0.35	25.50 ± 0.21	22.01 ± 3.83 ^b	17.86 ± 1.06	24.08 ± 0.16	20.97 ± 3.47 ^c	18.87 ± 1.20	25.99 ± 1.92
Total sugars (mg /100 g)	19.32 ± 0.31 ^a	-	-	15.75 ± 0.44 ^b	-	-	13.00 ± 0.14 ^c	-	-	16.03 ± 2.76	-
Reducing sugars (mg /100 g)	5.56 ± 0.12 ^a	-	-	4.15 ± 0.15 ^b	-	-	3.47 ± 0.06 ^c	-	-	4.40 ± 0.93	-
Non-Reducing sugars (mg /100 g)	13.76 ± 0.19 ^a	-	-	11.60 ± 0.31 ^b	-	-	9.53 ± 0.18 ^c	-	-	11.63 ± 1.84	-
Pectin (%)	3.75 ± 0.07	19.40 ± 0.12	11.58 ± 8.58 ^b	6.05 ± 0.14	19.93 ± 1.13	12.99 ± 7.64 ^a	3.99 ± 0.02	17.43 ± 0.19	10.71 ± 7.36 ^c	4.59 ± 1.10	18.92 ± 1.28

Note: The NS- Non Significant, * Significant at 0.05 per cent, ** Significant at 0.01 per cent

Table 3

	SEm±	CD			SEm±	CD
pH	0.501	0.28*	Titrateable Acidity	Portion	0.015	0.05*
Total Soluble Solids	0.498	2.612**		Variety	0.022	0.03**
Total Sugars	0.554	2.903**		PxV	0.037	0.15**
Reducing Sugars	0.363	1.905**	Ascorbic Acid	Portion	0.138	0.597**
Non Reducing Sugars	0.453	2.374**		Variety	0.187	0.829**
				PxV	0.315	1.361**
			Pectin	Portion	0.132	0.571**
				Variety	0.179	0.775**
				PxV	0.302	1.303**

Note 1: Values are mean of ten replications, SEm- Standard error of mean, CD- Critical difference, NS- Non Significant, * Significant @5%, ** Significant @ 1 %.Values with the same superscripts (a, b) in the same row are not significantly different (p≤0.01).

Table 4: Proximate Composition and Energy of Pulp and Peel of Mango

Portion of Fruit	Mango Varieties	Proximate Composition (% Dwb)						
		Moisture	Protein	Fat	Total Minerals	Crude Fibre	Carbohydrate	Energy (Kcal/ 100 g)
Pulp	Alphonso	83.19 ± 0.02	0.73 ± 0.03	0.82 ± 0.15	2.32 ± 0.07	0.68 ± 0.03	12.25 ± 0.10	59 ± 0.899
	Kesar	76.09 ± 0.15	0.98 ± 0.12	0.65 ± 0.04	1.52 ± 0.06	0.32 ± 0.03	20.44 ± 0.27	92 ± 0.632
	Totapuri	72.94 ± 0.11	0.59 ± 0.02	0.77 ± 0.11	1.88 ± 0.05	0.56 ± 0.02	23.32 ± 0.08	103 ± 1.081
Mean of pulp		77.41 ± 4.55	0.77 ± 0.18	0.75 ± 0.12	1.89 ± 0.35	0.52 ± 0.16	18.67 ± 4.98	85 ± 19.462
Peel	Alphonso	10.32 ± 0.95	0.86 ± 0.13	3.15 ± 0.059	3.41 ± 0.04	10.91 ± 0.85	71.35 ± 0.80	317 ± 2.810
	Kesar	10.40 ± 0.15	0.36 ± 0.05	3.72 ± 0.05	3.75 ± 0.09	10.72 ± 0.16	71.05 ± 0.36	319 ± 1.299
	Totapuri	10.56 ± 0.24	0.86 ± 0.25	3.88 ± 0.03	3.32 ± 0.05	10.20 ± 0.08	71.17 ± 0.22	323 ± 0.561
Mean of peel		10.43 ± 0.18	0.69 ± 0.26	3.59 ± 0.34	3.49 ± 0.21	10.61 ± 0.54	71.19 ± 0.47	320 ± 3.033
Mean of variety	Alphonso	46.71 ± 44.02 ^a	0.79 ± 0.12 ^a	1.99 ± 1.28 ^b	2.87 ± 0.60 ^a	5.79 ± 5.63 ^a	45.55 ± 36.48 ^c	203 ± 157.67 ^c
	Kesar	43.20 ± 40.05 ^b	0.67 ± 0.35 ^a	2.19 ± 1.68 ^a	2.64 ± 1.22 ^b	5.38 ± 5.28 ^a	49.46 ± 31.79 ^a	220 ± 140.95 ^b
	Totapuri	41.75 ± 38.77 ^c	0.73 ± 0.15 ^a	2.33 ± 1.71 ^a	2.57 ± 0.82 ^b	5.57 ± 5.20 ^a	48.82 ± 31.21 ^b	230 ± 139.23 ^a
Total		43.92 ± 34.60	0.73 ± 0.222	2.17 ± 1.48	2.69 ± 0.87	5.57 ± 5.20	44.93 ± 27.24	202 ± 121.831

Table 5

		Moisture	Protein	Fat	Minerals	Fiber	CHO	Calories
Factor A	SEM	0.073	0.054	0.056	0.048	0.115	0.11	0.23
	CD	0.073**	NS	0.241**	0.208**	0.495**	0.477**	0.974**
Factor B	SEM	0.10	0.073	0.075	0.065	0.155	0.148	0.311
	CD	0.425**	NS	0.325**	0.284**	NS	0.640**	1.347**
A x B	SEM	2121	0.123	0.126	0.110	0.261	0.225	0.525
	CD	0.714**	0.529**	0.546**	0.473**	NS	0.972**	2.266**

Note1: Values are mean of three replications, SEM- Standard error of mean, CD- Critical difference, NS- Non Significant, ** Significant @ 1 %.Values with the same superscripts (a, b, c) in the same column are not significantly different ($p \leq 0.01$),

Note2: Factor A- Between portion of fruit (pulp and peel), Factor B- Between Variety (Alphonso, Kesar, Totapuri)

Table 6: Mineral Content (Mg/100g) of Pulp and Peel of Mango

Mango	Varieties	Calcium	Phosphorus	Zinc	Iron	Manganese	Copper
Pulp	Alphonso	12.30 \pm 0.12	15.68 \pm 0.31	0.19 \pm 0.023	0.26 \pm 0.03	0.16 \pm 0.05	0.05 \pm 0.01
	Kesar	13.46 \pm 0.32	16.40 \pm 0.30	0.21 \pm 0.034	0.35 \pm 0.05	0.17 \pm 0.01	0.30 \pm 0.01
	Totapuri	12.54 \pm 0.02	15.13 \pm 0.11	0.18 \pm 0.019	0.22 \pm 0.00	0.13 \pm 0.03	0.04 \pm 0.01
Mean of Pulp		12.77 \pm 0.56	15.73 \pm 0.60	0.19 \pm 0.0264	0.28 \pm 0.07	0.15 \pm 0.03	0.04 \pm 0.01
Peel	Alphonso	18.57 \pm 0.09	20.95 \pm 0.06	0.19 \pm 0.000	0.48 \pm 0.03	0.25 \pm 0.01	0.04 \pm 0.00
	Kesar	17.76 \pm 0.19	19.06 \pm 0.02	0.29 \pm 0.093	0.58 \pm 0.20	0.34 \pm 0.02	0.11 \pm 0.02
	Totapuri	17.82 \pm 0.14	19.44 \pm 0.71	0.205 \pm 0.068	0.42 \pm 0.06	0.53 \pm 0.07	0.06 \pm 0.03
Mean of peel		18.05 \pm 0.41	19.82 \pm 0.94	0.228 \pm 0.075	0.49 \pm 0.13	0.37 \pm 0.13	0.07 \pm 0.04
Mean of Variety	Alphonso	15.43 \pm 3.44 ^{ab}	18.31 \pm 2.90 ^a	0.19 \pm 0.014 ^a	0.37 \pm 0.13 ^a	0.21 \pm 0.05 ^c	0.05 \pm 0.01 ^b
	Kesar	15.61 \pm 2.37 ^a	17.73 \pm 1.47 ^{ab}	0.25 \pm 0.077 ^a	0.46 \pm 0.18 ^a	0.26 \pm 0.10 ^b	0.07 \pm 0.05 ^a
	Totapuri	15.18 \pm 2.89 ^b	17.28 \pm 2.41 ^b	0.19 \pm 0.05 ^a	0.31 \pm 0.11 ^a	0.330 \pm 0.23 ^a	0.05 \pm 0.02 ^b
Grand mean		15.41 \pm 2.76	17.78 \pm 2.23	0.21 \pm 0.06	0.39 \pm 0.15	0.26 \pm 0.15	0.06 \pm 0.03

Table 7

		Ca	P	Zn	Fe	Mn	Cu
Portion	SEM \pm	0.080	0.113	0.026	0.151	0.156	0.021
	CD	0.347**	0.486**	NS	NS	0.674**	0.091**
Variety	SEM \pm	0.109	0.152	0.037	0.074	0.063	0.013
	CD	0.335**	0.658**	NS	0	0.273**	NS
Portion x Variety	SEM \pm	0.183	0.256	0.032	0.00	0.117	0.03
	CD	0.789**	1.107**	NS	NS	0.505**	0.137**

Note: Values are mean of three replications, SEM- Standard error of mean, CD- Critical difference, IDF- Insoluble dietary fiber, SDF- Soluble dietary fiber, TDF- Total Soluble fiber, ** Significant @ 1 %.Values with the same superscripts (a, b,c) in the same column are not significantly different ($p \leq 0.01$).

Table 8: Antinutrient Content of Pulp and Peel of Mango

Mango Varieties	Phytic acid (mg/100g)			Oxalates (%)		
	Pulp	Peel	Mean B	Pulp	Peel	Mean B
Alphonso	0.59 ± 0.11	25.53 ± 4.44	13.06 ± 13.95 ^{ab}	4.33 ± 0.03	5.95 ± 0.11	5.14 ± 0.890 ^c
Kesar	0.64 ± 0.17	33.70 ± 6.17	17.17 ± 18.53 ^a	4.06 ± 0.01	8.98 ± 0.19	6.52 ± 2.695 ^a
Totapuri	0.60 ± 0.10	17.20 ± 5.81	8.90 ± 9.81 ^b	4.54 ± 0.09	6.78 ± 0.10	5.66 ± 1.235 ^b
Mean A	0.61 ± 0.11	25.48 ± 8.60	13.04 ± 14.09	4.31 ± 0.21	7.24 ± 1.36	5.77 ± 1.778

Table 9

Mango	Phytic acid		Oxalates	
	SEm ±	CD	SEm ±	CD
Factor A	0.381	1.644 **	0.062	0.269**
Factor B	0.516	1.589*	0.085	0.366**
A x B	0.867	2.673*	0.141	0.611**

Table 10: Optimization of Green Gram Laddu Incorporated with Kesar Mango Peel

Green Gram Flour: Mango Peel	Appearance	Colour	Texture	Aroma	Flavour	Taste	Overall Acceptability	Acceptability Index
100:0	8.00 ± 0.14 ^a	8.10 ± 0.52 ^{ab}	8.00 ± 0.57 ^{ab}	7.80 ± 0.91 ^b	7.50 ± 0.81 ^b	7.90 ± 0.32 ^b	7.70 ± 0.60 ^b	87.30 ± 6.83 ^b
95:05	8.60 ± 0.52 ^a	8.70 ± 0.48 ^a	8.40 ± 0.70 ^{ab}	8.30 ± 0.82 ^{ab}	8.30 ± 0.68 ^{ab}	8.10 ± 0.74 ^{ab}	8.30 ± 0.68 ^{ab}	93.18 ± 5.45 ^{ab}
90:10	8.60 ± 0.52 ^a	8.60 ± 0.52 ^a	8.70 ± 0.48 ^a	8.30 ± 0.82 ^{ab}	8.20 ± 1.03 ^{ab}	8.50 ± 0.71 ^{ab}	8.50 ± 0.71 ^{ab}	94.29 ± 6.68 ^a
85:15	8.20 ± 0.42 ^a	8.30 ± 0.48 ^{ab}	8.50 ± 0.53 ^{ab}	8.60 ± 0.70 ^a	8.80 ± 0.42 ^a	8.80 ± 0.42 ^a	8.80 ± 0.42 ^a	95.24 ± 4.17 ^a
80:20	8.00 ± 0.94 ^a	7.70 ± 1.06 ^b	7.80 ± 0.63 ^b	7.60 ± 0.70 ^b	7.70 ± 0.95 ^b	7.80 ± 0.79 ^b	7.70 ± 0.82 ^b	86.19 ± 8.20 ^b
Total Mean	8.35 ± 0.66	8.33 ± 0.76	8.35 ± 0.66	8.20 ± 0.82	8.25 ± 0.87	8.30 ± 0.76	8.33 ± 0.76	92.22 ± 7.04
'F' value	2.250	4.365	4.286	3.086	3.128	4.193	4.767	4.257
SEM±	0.102	0.110	0.102	0.114	0.117	0.109	0.110	0.337
CD	NS	0.315*	0.293*	0.327*	0.336*	0.314*	0.423**	0.966*

Note: Values are mean of three replications, SEm- Standard error of mean, CD- Critical difference, NS- Non Significant,

* Significant @ 5%,** Significant @ 1 %.Values with the same superscripts (a, b, c) in the same column are not significantly different (p≤0.01)

Table 11: Organoleptic Evaluation of Green Gram Laddu Incorporated with Mango Peel

Mango peel Incorporated laddu	Appearance	Colour	Texture	Aroma	Flavour	Taste	Overall Acceptability	Acceptability Index
Alphonso	7.80 ± 0.63 ^a	7.20 ± 0.42 ^b	6.60 ± 0.52 ^b	7.20 ± 0.79 ^b	7.40 ± 0.97 ^b	7.40 ± 0.97 ^a	7.50 ± 0.53 ^b	80.80 ± 3.55 ^b
Kesar	8.20 ± 0.42 ^a	8.30 ± 0.48 ^{ab}	8.50 ± 0.53 ^{ab}	8.60 ± 0.70 ^a	8.80 ± 0.42 ^a	8.80 ± 0.42 ^a	8.80 ± 0.42 ^a	95.24 ± 4.17 ^a
Totapuri	7.90 ± 0.88 ^a	7.70 ± 0.48 ^a	7.30 ± 0.48 ^a	7.50 ± 0.53 ^{ab}	7.30 ± 0.95 ^b	7.60 ± 1.17 ^a	7.70 ± 0.48 ^{ab}	84.13 ± 4.49 ^a
Grand Mean	7.97 ± 0.77	7.53 ± 0.51	7.03 ± 0.56	7.53 ± 0.73	7.70 ± 0.99	7.47 ± 0.90	7.80 ± 0.61	86.33 ± 4.54
'F' value	0.727	3.879	6.344	2.562	10.230	0.155	4.280	8.639
SEM±	0.118	0.096	0.101	0.115	0.134	0.128	0.106	0.288
CD	NS	0.279*	0.395**	0.335*	0.526**	NS	0.306*	1.128**

Note: Values are mean of three replications, SEm- Standard error of mean, CD- Critical difference, NS- Non Significant,

* Significant @ 5%,** Significant @ 1 %.Values with the same superscripts (a, b, c) in the same column are not significantly different (p≤0.01)

Table 12: Effect of Incorporation of Mango Peel Powder on Nutrient Composition of Green Gram Laddu

Nutrients (per 100g)	Green Gram Laddu	Green Gram Laddu incorporated with Mango Peel Powder
Moisture	13.02	13.69
Protein	13.19	11.26
Fat	12.06	12.62
Crude fiber	4.65	5.55
Carbohydrate	54.86	65.52
Energy (Kcal)	439	421
B-Carotene ($\mu\text{g}/100\text{g}$)	44.2	202.39
Calcium ($\text{mg}/100\text{g}$)	40.54	37.11
Phosphorus ($\text{mg}/100\text{g}$)	132.92	188.94
Zinc ($\text{mg}/100\text{g}$)	1.51	1.32
Iron ($\text{mg}/100\text{g}$)	1.87	2.11
Manganese ($\text{mg}/100\text{g}$)	0.66	0.73
Copper ($\text{mg}/100\text{g}$)	0.67	0.78

* Kesar variety peel powder @ 15%

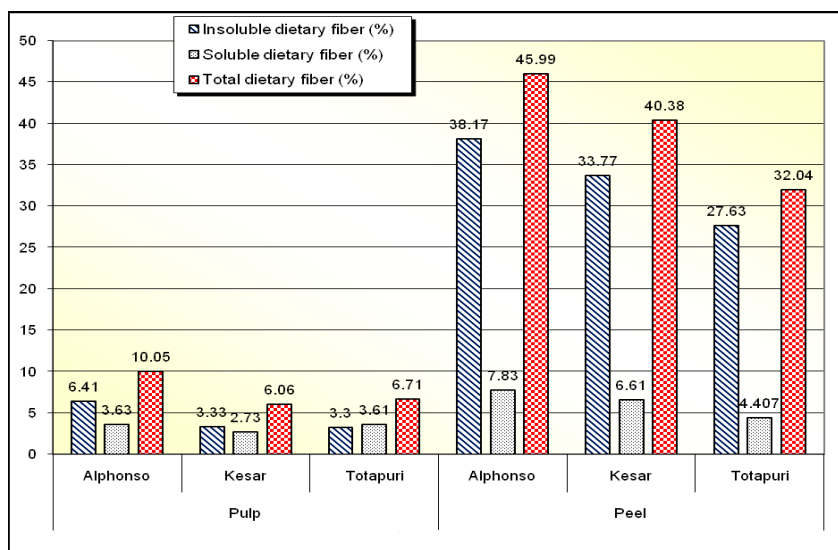


Figure 1: Dietary Fiber Content of Pulp and Peel of Mango

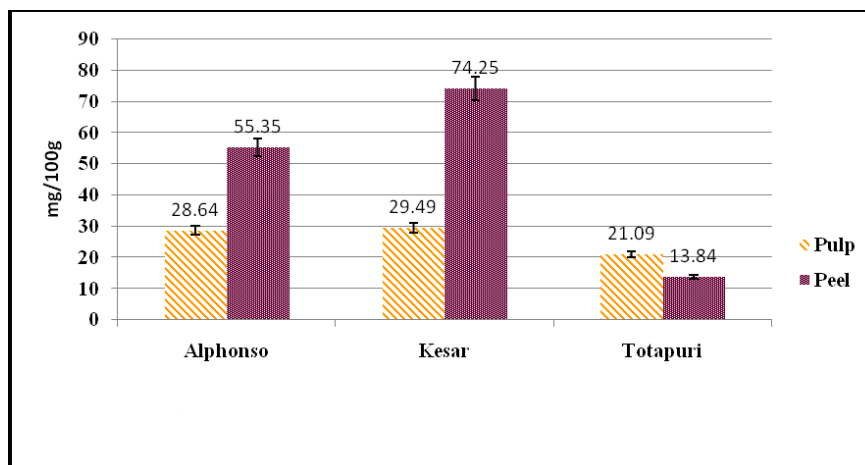


Figure 2: B-Carotene Content of Pulp and Peel of Mango Varieties